Designation: D 645 – 92

Standard Test Method for Thickness of Paper and Paperboard[1]

This standard is issued under the fixed designation D 645; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method covers the determination of the thickness of paper and paperboard except electrical insulating papers (see Methods D 202).

1.1.1 Because of the relatively high pressure (50 kPa) used in this test method, it may not be suitable for measurement of tissue or other soft or low density materials, because the structure may collapse (decrease in thickness) at the prescribed pressure of 50 kPa.

1.2 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 202 Methods of Sampling and Testing Untreated Paper Used for Electrical Insulation[2]

D 585 Methods for Sampling and Accepting a Single Lot of Paper, Paperboard, Fiberboard, or Related Product[2]

D 685 Method of Conditioning Paper and Paper Products for Testing[2]

D 1968 Terminology Relating to Paper and Paper Products[2]

2.2 *TAPPI Standards:*

T 411 Thickness (caliper) of paper, paperboard, and combination board[3]

T 1206 Precision statements for test methods[3]

3. Terminology

3.1 Definitions shall be in accordance with Terminology D 1968 and the *Dictionary of Paper.*[4]

3.2 *Description of Term Specific to This Standard:*

3.2.1 *thickness paper or paperboard*—the perpendicular distance between the two principal surfaces of the paper or paperboard under specific conditions.

4. Significance and Use

4.1 Thickness is an important property of paper or paperboard, critical for certain end uses of paper and paperboard. This test method is useful for research work, routine control, design of end-use products, and for acceptance testing for conformance to a specification. Apparent density and other paper properties are related to thickness.

5. Apparatus

5.1 *Micrometer*, conforming to the following specifications:

5.1.1 Motor operated, dead-weight (not spring) actuated.

5.1.2 The micrometer shall have a flat ground circular movable face (the presser foot), having an area of 200 ± 5 mm² (equivalent to about 0.31 ± 0.01 in.²) and corresponding to a diameter of 16 ± 0.2 mm (0.63 ± 0.01 in.).

5.1.3 The micrometer shall have a flat ground circular fixed face (the anvil) of such size that it is in contact with the whole area of the pressure foot in the zero position.

5.1.4 The surface of the presser foot shall be parallel to the surface of the anvil to within 0.001 mm (0.00005 in.). The presser foot movement shall be on an axis that is perpendicular to the anvil surface. The minimum distance between the anvil and the presser foot in the "up" or raised position shall be 0.75 mm (0.030 in.).

5.1.5 The presser foot, when lowered, shall exert steady pressure on the specimen of 50 ± 2 kPa (approximately 7.3 ± 0.3 psi or 0.51 kgf/cm²) for 3 ± 1 s. The period of steady pressure on the specimen is referred to as dwell time.

5.1.6 The presser foot shall have a lowering speed of 0.8 ± 0.1 mm (0.03 ± 0.004 in.)/s.

5.1.7 The frame of the micrometer shall be of such rigidity that a load of 3 lb (1.5 kg) applied to the dial housing, out of contact with either the weight or the presser foot spindle, will produce a deflection of the frame not greater than 0.0001 in. (0.0025 mm), as indicated by the micrometer readout system.

5.2 *Readout System*—Two types of readout systems are available for use in this test method as follows:

5.2.1 *Dial-Type System* with a dial, graduated to 0.002 mm (0.0001 in.) or less, readable to at least 0.001 mm (0.00005 in.), or 1 % of paper thickness, whichever is larger. If the large indicating hand of the dial is required to revolve more than once to cover the capacity of the gage, equip the dial with a revolution counter to indicate the number of complete revolutions of the indicating hand.

5.2.2 *Digital-Type Readout System*, with a digital display indication to at least 0.001 mm (0.00005 in.), or 1 % of paper thickness, whichever is larger.

5.2.3 The readout system used shall be capable of repeating readings to within 0.001 mm (0.00005 in.) at zero settings or on a steel gage block.

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[1] This test method is under the jurisdiction of ASTM Committee D-6 on Paper and Paper Products and is the direct responsibility of Subcommittee D06.92 on Test Methods.

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[2] *Annual Book of ASTM Standards*, Vol 15.09.

[3] Available from the Technical Association of the Pulp and Paper Industry, Technology Park, P.O. Box 105113, Atlanta, GA 30348.

[4] Formerly published by American Paper and Pulp Assoc. (currently API), New York, NY.

6. Calibration

6.1 Measurements are made on standard steel gages with the thickness known within 0.00003 in. (0.0008 mm). The measurements shall be within the following tolerances:

Intervals	Permissible Deviation of Reading from Actual Thickness of Standard Steel Gage
0 to 0.01 in. (0.25 mm)	± 0.00005 in. (0.0012 mm)
Over 0.01 in.	± 0.0002 in. (0.005 mm)

NOTE 1—In the use of steel gages made of a nondeformable material, it must be remembered that the value corresponding to the thickest portion of the gage, rather than the average thickness, should be used in the calibration of paper micrometers.

6.1.1 Apply the deviations for the parts of the scale corresponding to the specimen thickness measured as corrections to the thickness reading.

6.2 *Parallelism of the Faces*—Use a uniform diameter wire of any size up to half the operational opening of the faces (for example, 0.020 in. diameter). Alternate the wire on the left side, right side, front side, and back side approximately ⅛ in. from each respective edge of the foot. Note the readings. Adjust the anvil so that all readings are within 0.00005 in. of one another.

NOTE 2—An acceptable alternative to the thin wire described above is a hard steel ball, 1 mm or less in diameter, fixed in a thin (less than 1 mm in thickness) flat piece of metal, or else the tip of a feeler gage of about the same thickness specified for the wire. Use any of the three devices as described in 6.2.

6.3 The frame of the micrometer shall be of such rigidity that a load of 3 lb (1.5 kg) applied to the dial housing, out of contact with either the weight or the presser foot spindle, will produce a deflection of the frame not greater than 0.0001 in. (0.0025 mm), as indicated by the micrometer readout system.

7. Test Specimens

7.1 Obtain specimens from samples obtained in accordance with Methods D 585.

NOTE 3—Some paper manufacturers and users measure the thickness of papers 0.051 mm and under using a specimen that contains eight or ten sheets of paper. Usually, but not always, if a micrometer is used to measure the thickness of a single sheet of this thinness, the error in reading the instrument is likely to make a significant difference in the result. If a pile of 10 sheets is measured and the result divided by 10, there will also be an error due to the "piling effect," but the latter error will, in general, be smaller than the former. In existing specification documents the values for thickness of thin papers (0.051 mm or less) may require modification if this single sheet method is referenced in that material specification document.

8. Conditioning

8.1 Condition all specimens in accordance with Method D 685 prior to testing for thickness. Conduct all tests for thickness in a room or chamber in which the atmospheric conditions of Method D 685 are maintained.

9. Procedure

9.1 *General*—Before using any micrometer, make sure that the presser foot and anvil surfaces are clean, that the calibration of the instrument has been verified and a calibration curve has been prepared, if necessary, and that the instrument is mounted on a solid level surface free from noticeable vibration.

9.2 Place the specimen on the anvil in such a position that all points on the peripheries of the contact surface are at least 0.25 in. (6 mm) from the edges of the specimen.

9.2.1 When using multiple-sheet test specimens including combined paperboard, the presser foot shall not be closer than 20 mm (0.75 in.) from any edge of the stack.

9.3 Take a specified number of measurements mutually agreed upon between the producer and the consumer. Measure at regular intervals across the entire width of each specimen, preferably in a line that is at right angles to the machine direction of the paper. In all cases, make at least five such measurements on each specimen, except if only an estimate of lot or test unit average is required (that is, variations of thickness within a sheet are of no interest). Then only two readings per specimen need be made.

9.4 Take each reading near the end of the dwell time. If necessary, apply the calibration corrections to the readings.

9.5 If the thickness of noticeably compressible papers is being measured, it is particularly important that the rate of fall of the presser foot and the dwell time be within the specified limits. (See 5.1.5 and 5.1.6.) Examples of noticeably compressible papers include tissue paper, or other soft or low-density papers.

10. Report

10.1 Report the following information:

10.1.1 The corrected values of average, maximum, and minimum thickness obtained on each test specimen, except where, by agreement between producer and consumer, only two tests per specimen have been made. Then only the average need be reported.

10.1.2 The method used.

10.1.3 The number of readings taken on each specimen.

10.2 Thickness may be expressed in any applicable units of distance such as millimetres, inches, mils, etc., as agreed upon by producer and consumer.

11. Precision and Bias

11.1 *Precision:*

11.1.1 *Repeatability*—1.25 %.

11.1.2 *Reproducibility*—5.50 %.

11.1.3 The above precision was calculated from data taken from 24 reports of the *Collaborative Reference Program for Paper*,[4] using procedures for calculation as specified in TAPPI T 1206.

11.1.4 The user of this precision data is advised that it is based on actual mill testing, laboratory testing, or both. There is no knowledge as to the exact degree to which personnel skills or equipment were optimized during its generation. The precision provides an estimate of typical variation in test results which may be encountered when this test method is used by two or more parties.

11.2 *Bias*—The procedure in this test method has no bias because the value of thickness is defined only in terms of the testing conditions specified in this method.

12. Keywords

12.1 caliper paper; paperboard; thickness

APPENDIXES

(Nonmandatory Information)

X1. MANUALLY OPERATED MICROMETER

X1.1 The manually operated micrometer does not conform to this test method. This Appendix simply gives general information on use of such a micrometer, as many are still in use.

X1.2 *Apparatus:*

X1.2.1 *Dial-Type Micrometer*—Manually-operated, deadweight actuated, conforming in general to the requirements for the motor-operated instrument.

X1.3 *Procedure:*

X1.3.1 Place the specimen between the contact surfaces and lower the pressure foot onto the specimen at a location outside of the area to be measured. Note this trial reading. Raise the pressure foot, move the specimen to the measurement position, lower the pressure foot to within 0.008 mm (0.0003 in.) of the surface of the specimen (that is, to the previous reading plus 0.008 mm) and then release the pressure foot.

X1.3.2 For each succeeding measurement, raise the pressure foot, move the specimen to the next measurement location, and lower the pressure foot to within 0.008 mm (0.0003 in.) of the surface of the specimen (as defined by the previous reading) before releasing the pressure foot.

X1.3.3 As an alternative technique, recommended when the variations in specimen thickness are greater than 0.008 mm, lower the pressure foot at some velocity less than 12 mm (0.5 in.)/s onto the surface of the paper specimen.

X1.3.4 Repeat, making five readings per specimen, excluding the trial reading.

X1.4 *Precision and accuracy:*

X1.4.1 Because of the greater influence of the operator, the manually-operated instrument has shown less agreement among laboratories than the motorized instrument. Properly and skillfully operated, the accuracy of the manually operated instrument should be as good as that of the motorized instrument except possibly on highly compressible papers for which differences of 3 % have been reported.

X2. DIFFERENCES BETWEEN ISO 534 AND TEST METHOD D 645

X2.1 Both the ASTM and TAPPI (T411) test methods specify a pressure between the foot and the anvil of the micrometer of 50 ± 2 kPa. ISO 534 specifies the pressure of 100 ± 10 kPa as the "preferred" and 50 ± 5 kPa as an "alternative." An instrument conforming with the ISO standard of 100 kPa is likely to give lower values than an instrument conforming to the ASTM standard, with the difference a function of compressibility of the paper.